

Professional Perceptions of Six Sigma's Value

Jerusha Myrick¹, Tracy Burkhardt³, Linda Nelms², Steve Patch⁴, and Robert Yearout²

¹Laser Precision Cutting, Inc.
181 Reems Creek Road
Weaverville, NC 284787

²Department of Management & Accountancy
University of North Carolina Asheville
Asheville, NC 28804

³Volvo Construction Equipment Rents, Inc.
One Volvo Drive
Asheville, NC 28803

⁴Department of Mathematics
University of North Carolina at Asheville
Asheville, NC 28804

Corresponding author's e-mail: {Robert Yearout, yearout@unca.edu }

At the 2008 American Society of Quality (ASQ) World Conference on Quality and Improvement in Houston, Texas, generational diversity and knowledge transfer were two areas of focus. Quality methodology and tools have not changed much over the years. However, these practices and techniques have been repackaged and sold to upper management as the latest and greatest cure for what ails the company. With each acceptance of a repackaged methodology aging professionals are replaced by advocates of the latest methods that promise greater productivity. Lean Six Sigma and Six Sigma are the current corporate management approaches that have been marketed widely. The selling point for such initiatives is the promise that a large return on investment (ROI) can be realized. A survey was developed to compare the cost of implementing a program such as Lean Manufacturing, Six Sigma or Lean Six Sigma for various size organizations. The survey, which was divided into an initial and a follow-on survey, was administered to professionals who are employed in some field where implementations have been perceived as successful to one extent or another. The survey's focus was to explore whether there are situations where the promise is not kept and/or where there are situations where the impact of the cultural change does not justify the effort. Based upon the occupations of the volunteer subjects, there is a very high possibility of a positive bias in the results. While survey results were generally quiet supportive of the methodologies and would lead to a recommendation for the adoption of one of the programs, it is necessary for there to be further study.

Significance: To insure the potential gains to the organization are sufficient to finance the necessary investments, management, engineers, and quality specialists should assess, evaluate, and review, the current performance level with the potential gains before embarking on a six sigma initiative.

Key Words: Six Sigma, Lean Six Sigma, Lean Methodology

(Received: 13 May 2009; Accepted in revised form: 16 June 2009)

1. INTRODUCTION

In Six Sigma Training, History, Definitions-Six Sigma and Quality Glossary (2009), Six Sigma is touted as being the "most popular management methodology in history." Six Sigma has been implemented in diverse environments including government agencies, hospitals, military complexes, banks and multinational corporations. The website, *businessballs.com*, expounds on the big business of selling Six Sigma stating:

"Many organizations and suppliers in the consulting and training communities have also seized on the Six Sigma concept, to package and provide all sorts of Six Sigma 'branded' training products and

consultancy and services. Six Sigma has also spawned many and various business books on the subject. Six Sigma, it might seem, is taking over the world.” (businessballs.com, 2008)

According to Donna C. S. Summers’ book, *Six Sigma, Basic Tools and Techniques* (2007), it is not a secret that the Six Sigma methodology is a blend of existing quality initiatives. David Silverstein, managing partner at Breakthrough Management Group, explains why companies should take the necessary steps and invest the capital for implementation in Vanessa R. Franco’s article (2001), *Adopting Six Sigma*.

“Six Sigma is, in fact, very special,” he maintains. “There is certainly truth to the statement that few of the individual elements of Six Sigma represent new thinking. What is special about Six Sigma is that it puts all of the elements together in a comprehensive system that’s structured and disciplined and includes many points of accountability. I liken it to going to classes or seminars and reading books and always saying, ‘Wow, that really should make my business better,’ but then ultimately being disappointed. In Six Sigma, we’re attacking the organizational issues that led us to be disappointed by otherwise great programs. That means tying in the management team, the support functions (human resources, finance, communications, and information technology) and all other employees.”

The history of quality began with inspection processes which worked well with low production volumes but as manufacturing achieved higher levels of production, the need for better inspection processes also increased. Frederick Taylor published *“The Principles of Scientific Management”* in 1911 which defined inspection as a process which focused on 100% part inspection after completion. Taylor’s publication resulted in the development of a separate inspection department in many organizations. This evolved into quality control with a focus on defect prevention. In 1924, Dr. W. Shewhart developed statistical analysis methods to apply to quality control. His methods involved testing samples throughout the manufacturing process instead of doing 100% piece inspection after completion. The testing results would be used to infer compliance of all products. In the early 1950s, Deming expanded the statistical analysis with management commitment to quality. Concurrently, Juran became familiar with Vilfredo Pareto’s 1941 principle that espoused that 80% of a problem is a direct result of 20% of the associated causes. Juran applied the Pareto principle to manufacturing. Juran then introduced his trilogy approach to management;

- 1) quality planning – identify customers and their needs, develop a product which meets the customers’ needs and the company’s internal needs;
- 2) quality improvement – develop and optimize the process to produce the pre-defined product and
- 3) quality control – produce the product to meet standards repeatedly with minimum inspection.

Quality circles, where members would regularly meet to discuss how to improve any aspect of the operations and deliver their findings to management, emerged in the 60s.

In the 1980’s, Total Quality Management (TQM) became the new approach to quality. TQM expanded quality principles to encompass the whole organization. Quality principals related to customer focus, continuous improvement and employee involvement. In 1988, the Malcolm Baldrige Award was developed by the United States government. The standard developed for the award became the first TQM model that was recognized internationally. The government hoped American companies would adopt the principals to make their companies more competitive because it was becoming apparent that *“The World is Flat”* even before that catch phrase had been used by Thomas L. Friedman (Juran, 1995). In the midst of TQM and Malcolm Baldrige awards, the ISO 9000 series and QS 9000 were created. These were standards that applied to quality management systems. Companies could achieve the standards, hire independent auditors to confirm the achievement, and then become registered as ISO or QS compliant. These standards were revised repeatedly by committees of quality professionals recognized as the experts in quality. Revised standards required registered companies to revise their existing quality management systems and become upgraded by the organizations. The evolution of quality in business has been a process of growing and learning and the newest trends have always included elements that the quality pilgrims introduced. It is easy to recall some of the previous initiatives now contributing to Six Sigma and Lean Six Sigma. Some of these include the Deming/Shewart Plan-Do-Check-Act cycle; Deming’s 14 Points and 7 Deadly Diseases; Shewart’s control chart; and TQM. The following two figures illustrate a comparison of the Deming/Shewart cycle (figure 1) to the Sigma cycle (figure 2).

Six Sigma originated at Motorola under the direction of Bill Smith and Mikel Harry. An analysis by Smith showed that a direct correlation existed between the quality and length of a product’s field life and the amount of rework during manufacturing. The analysis also showed that the best performing products were manufactured with the least

nonconformity. Harry devised the Define, Measure, Analyze, Improve, and Control Method as an approach to find problems and eliminate defects (figure 2). In 1987, Motorola launched the Six Sigma Quality Program and six sigma became the required capability level to achieve the standard of 3.4 Defects per Million Opportunities.

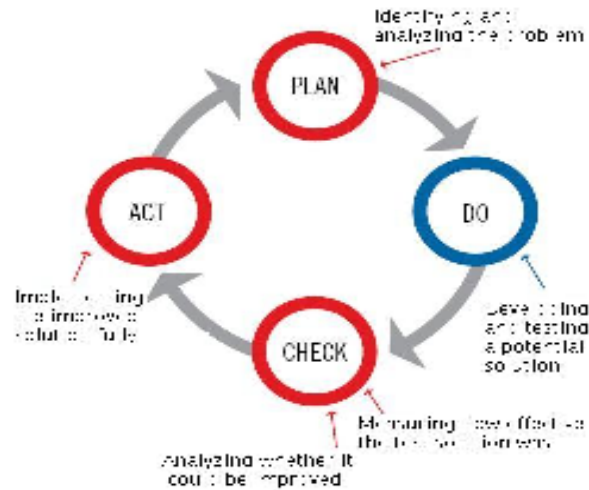


Figure 1. Plan, Do, Check Act Circle

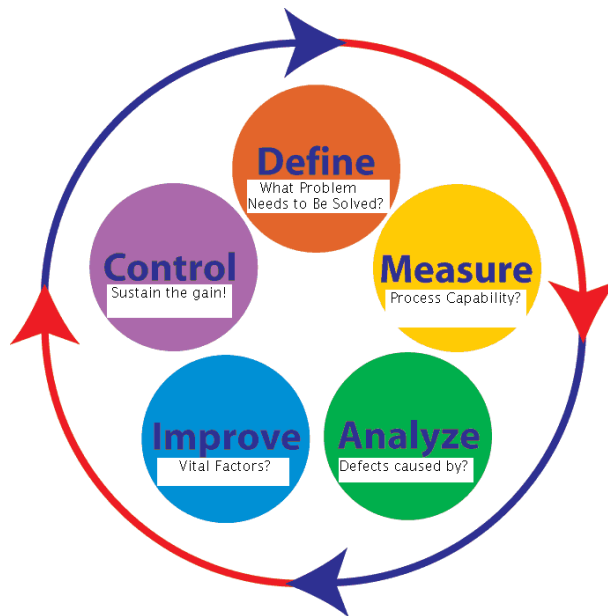


Figure 2. DMAIC Cycle

The new standard was to be used in all business aspects; that are in products, processes, services and administration. In six sigma, the common measurement index is DPMO (Defects per Million Operations, Opportunities, or Outputs) and can include anything from a component, piece of material, or line of code, to an administrative form, time frame or distance. Sigma (σ) is a Greek letter used to symbolize the standard deviation of a process. The standard deviation can be used to estimate the likelihood of a defect. The sigma level of a process is the number of standard deviations between the mean of the process and the nearest specification limit. The higher the sigma level, the less likely the process will create defects. From a management standpoint, higher sigma levels equate to cost and defect reductions, shorter cycle time, product and service improvements, increased productivity, and ultimately, increased customer satisfaction. To understand six sigma, it is necessary to have a basic understanding of process capability. A range of acceptable values is given for a specific

measurement, with an upper and lower limit known as the specification limits. The mid-point is usually the target value. Long-running processes often have means that shift during the process due to a variety of factors including tool wear and raw material inconsistencies. D.H. Evans suggested the use of 1.5σ as the potential shift in the mean of long term processes to determine the percentage of the output not within the specification limits. Harry confirmed Evans findings in 1988 in *The Nature of Six Sigma Quality*. Table 1 shows short term and long term process capability for several sigma levels.

Table 1. Short Term Process Capability and Long Term Process Capability

Short Term Process Capability			Long Term Process Capability		
Sigma	% Defective	DPMO	Sigma	% Defective	DPMO
2	4.55	45500	2	30.85	308,537
3	0.27	2700	3	6.68	66,807
4	0.0063	63	4	0.621	6,210
5	0.000057	.57	5	0.0324	233
6	0.0000002	.002	6	0.00034	3.4

The chart at figure 3 shows how Evans 1.5σ plays into the long-term process capability sigma levels.

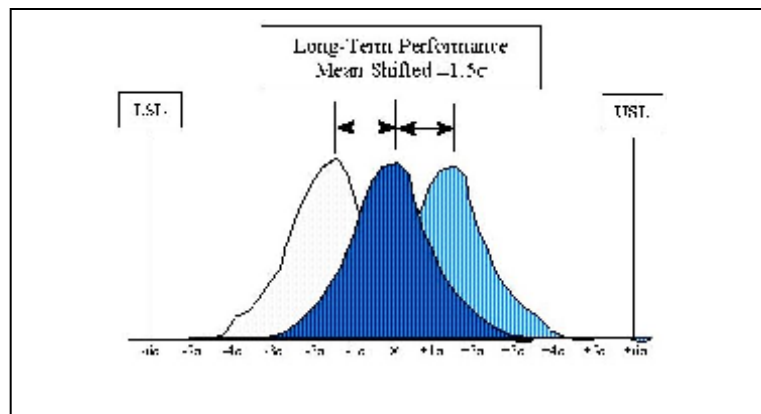


Figure 3. Evans 1.5σ

Note: USL: upper specification limit
 LSL: lower specification limit

In 1989, Harry became the top executive in Motorola's Six Sigma Research Institute. His goal was to develop a system that would result in "short cycle quality knowledge transfer and rapid dissemination of quality knowledge into a world-wide company". Harry devised a strategy that equipped workers and managers with quality tools, expanding the six sigma skills from the quality department throughout the organization. As a result of the success at Motorola and Harry's personal experience in business, Harry realized a market existed for his Six Sigma Quality Program because top executives are interested in programs/solutions that yield quantifiable gains. He created a ranking system for the different levels of six sigma training and skills. The highest level that could be attained was Champion, followed by Master Black Belt, Black Belt, and Green Belt. Motorola's success with Harry's six sigma approach gained attention in the business realm and several companies developed similar systems, (i.e., Texas Instruments). In 1993, Allied Signal hired Harry and adopted the six sigma approach. Allied Signal's CEO, Larry Bossidy wanted the top executives in his organization to understand the Six Sigma tools. Harry revised his six sigma methodology to include steps for project selection to those projects that had the greatest potential for high financial returns. Bossidy shared his experiences and profitable results with Jack Welch, the CEO of General Electric. Welch asked Bossidy to share these experiences at GE's Corporate Executive Council meeting. GE's top management conducted a cost-benefit analysis on the implementation of six sigma in their operations, which at the time were approximately at a three or four sigma level. The analysis showed the savings of a six sigma program to fall in a range of \$7 to \$10 billion dollars. With such numbers listed as a possibility, Jack Welch launched Six Sigma at GE in

January, 1998. Speaking to the corporate executives, Welch said *“Quality can truly change GE from one of the great companies to absolutely the greatest company in world business.... Everyone in this room must lead the quality charge. There can be no spectators on this. What took Motorola ten years, we must do in five - not through shortcuts, but in learning from others”*.

Jack Welch is today a “household name” in the majority of industrial board rooms and executive offices throughout the world. Many Fortune 500 companies have praised the six sigma and the lean six sigma methodologies and the competitive advantage the companies had gained, but some of those companies are experiencing difficulties in the current economically stressed times. Some examples of these less fortunate Fortune 500 companies are Motorola, Gateway, GE and 3M. Motorola claims to have saved \$16 billion due to six sigma and lean six sigma from 1986 to 2001. However, they posted a fourth-quarter loss of \$3.6 billion in 2008 after cutting 4,000 jobs (or is this just another example of them applying Lean?) and scaled back their software and mobile drive business. Analysts are predicting competition will contribute to Motorola’s problem in 2009 which means that they are breaking Jack Welch’s Rule #2 to, *“Be No. 1 or 2 in your market.”* The company’s current financial difficulties and economic situation do not mean that Motorola is going to begin looking for a new methodology; after all they continue to sponsor their University that charges approximately \$3000 for a week-long Green Belt Training and \$14,000 for a four-week Black Belt training. Gateway was purchased by a Taiwan computer manufacturer, Acer, in the fall of 2007 for \$1.90 per share; 2.25% of the high share price of \$84.00 set in November of 1999. GE stocks were worth approximately \$12.00 in February, 20% of their all time high in August, 2000 at \$60.50. Will the companies who have successfully implemented Six Sigma be more successful in surviving the economic downturn than those who have not? This is one of those questions that only time will answer.

Appendix A is a sampling of pricing for online and on-site training to achieve Lean Six Sigma/Six Sigma Green and Black Belt training. Costs are the quoted price for the training. For Green Belts this ranged from \$99.00 to \$7495.00 with a mean cost of \$3219.08 ($s = \2231.95). For Black Belt training the cost ranged from \$199.00 to \$14,950.00 with a mean cost of \$6152.84 ($s = \4545.55). If one would follow the prescribed certification procedure, training tuition cost would range from \$298.00 to \$18,169.08. The quoted on-site training costs do not include travel and per diem expenses. The inconsistent training costs lead one to consider whether a quality issue with the certification process exists.

An article in a 2007 issue of Chief Executive, *Deep Sixing Six Sigma*, examines the long term return for six sigma using a data analysis performed by QualPro, a Knoxville, Tennessee consulting firm. The data was based on 58 companies with “broad” six sigma programs. QualPro analyzed stock performance for these companies since the inception of their six sigma programs. Amazingly, only 5 of the 58 companies had stock performances that exceeded the S&P 500 index. It must be noted that pre-six sigma data was not included in the report nor is it available from other sources. Two company examples used were Ford and Home Depot. Ford launched Six Sigma in January of 2000, training over 2000 black belts to lead the effort. The hope was to improve customer satisfaction and shareholder value. The bottom line showed that since the implementation, Ford has actually been below the S&P 500 by over sixty percent. Home Depot implemented Six Sigma in 2001 and has since been below the S&P 500 by approximately thirty percent.

six sigma and lean six sigma approaches have also sparked questions about whether the efficiency may result in sacrifices the creativity that many companies need to survive.

In the June 11, 2007 issue of Business Week, an article, *At 3M, A Struggle between Efficiency and Creativity*, addresses this issue after James McNerney abruptly left 3M for Boeing. McNerney was recruited by 3M when he was not chosen to fill Welch’s shoes at General Electric. He transformed 3M operations using principals of six sigma and techniques he had learned from Jack Welch. He cut the workforce by 11%, reined in spending, trained Six Sigma Black Belts and *“won accolades for bringing discipline to an organization that had become unwieldy, erratic, and sluggish.”* However, McNerney’s management style may have been detrimental to the creativity that had defined 3M for many years. George Buckley, 3M’s current CEO, stated, *“Invention is by its very nature a disorderly process. You can’t put a Six Sigma process into that area and say, ‘Well, I am getting behind on invention, so I’m going to schedule myself for three good ideas on Wednesday and two on Friday’. That’s not how creativity works.”*

2. METHODOLOGY

A survey was developed to compare the cost of implementing a program such as Lean Manufacturing (Lean), Six Sigma or Lean Six Sigma for various size organizations. The survey addressed a variety of questions and was divided into two different parts which will be explained later. The survey was emailed to several contacts found through ASQ who had experience with six sigma programs. It was also posted in four groups on LinkedIn, a business-oriented professional networking website. The LinkedIn groups were Continuous Improvement, Six Sigma & Lean Group (total of 6,988 members); Six Sigma Network (4,224 members); Lean Six Sigma (12,355); Six Sigma for Business (3,792 members); Six Sigma Network Group (1,591 members). The first part of the survey asked questions about the costs for implementation, training and maintenance for the program and followed those questions by requesting the estimated return on investment

for the program. The second part was related to overall results, such as employee and customer satisfaction, company profitability and competitive advantage.

2.1 Initial Survey

The first part of the survey began with the respondent clarifying which system, Six Sigma, Lean Six Sigma or Lean, their organization had in place and for what length of time. General questions about the cost for implementation, training, and maintenance were included. Size of the organization was also included because many people feel these quality systems only work in larger organizations. The ratios of black and green belts to total number employed were included in the survey because of questions by many quality professionals about the number needed in different size organizations. The final question was the return of investment after the first year of adoption of the quality system.

2.2 Follow-up Survey

In the second part, the questions were more geared toward the impact on the organization and the customers. This survey was designed as an eleven point psychometric Likert scale commonly used to obtain perceptual data. The scale ranged from '1' Disagree to '11' Agree with point '6' being Neutral. The first questions address the transformation of the organization's business practices after the implementation of the program and the impact on customer satisfaction and the organization's profitability. The fourth question asks about the employees' satisfaction with their job duties. The next three questions are about internal quality and organizational growth and external competitive advantage. Questions 8 and 9 were gauges to relate the respondent's level of knowledge of the quality system to the authors.

3. SURVEY RESULTS

3.1 Initial Survey

There were seventy responses to the initial survey. Of the seventy responses to the first question, "What discipline is your organization using?" 51 (73%) organizations were using Lean Six Sigma, 8 organizations (11%) were using Six Sigma, and 11 (16%) organizations were using Lean methodology (figure 4). Figure 5 illustrates the number of years that the organizations represented have been using one of the three programs. Twenty-eight percent of those surveyed stated that their organizations' programs had been in place for 3 years. Whereas 7 percent reported that their program had been in place for less than one-half a year and 9 percent reported that their program had been in place for fifteen years.

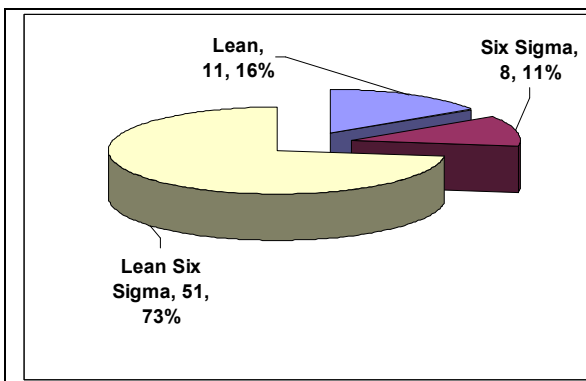


Figure 4. Organizational Program
 Note: Legend (program, count, percent)

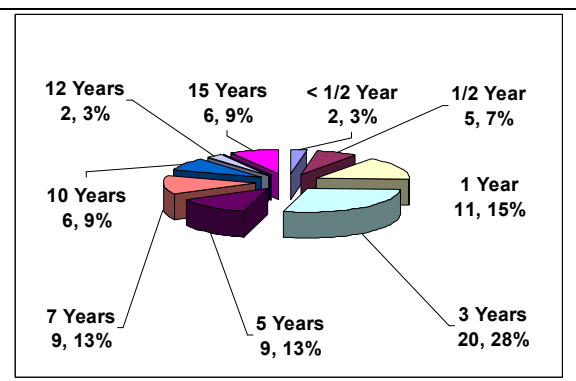


Figure 5. Years Program Has Been in Place
 Note: Legend (years, count, percent)

The next two questions were related to the cost to the organization for implementing and maintaining any of the three programs. Twenty-nine of the 59 (50%) of those surveyed responded that the initial training and implementation of their program exceeded \$101,000 (figure 6). Only 5 respondents (8%) reported that the cost to implement a program was less than \$5,000. Twenty-four out of 53 respondents (48%) stated that the cost to maintain the program exceeded \$101,000 annually (figure 7). Whereas seven (13%) stated their maintenance cost was less than \$5,000 annually.

Thirty percent (17) of the 58 who responded indicated that the cost to train a Green Belt was between \$1,000 and \$3,000 (figure 8). Another 12 respondents (21%) stated that the cost was less than \$1,000. Only 2 respondents (5%) stated that the cost exceeded \$15,000. The cost to train a Black Belt was reported by 15 respondents (27%) to be greater than \$15,000 with another 8 (14%) stating that the cost was between \$10,000 to \$15,000. Five respondents (9%) stated that their cost to train a Black Belt was between \$1,000 and \$3,000 (figure 9).

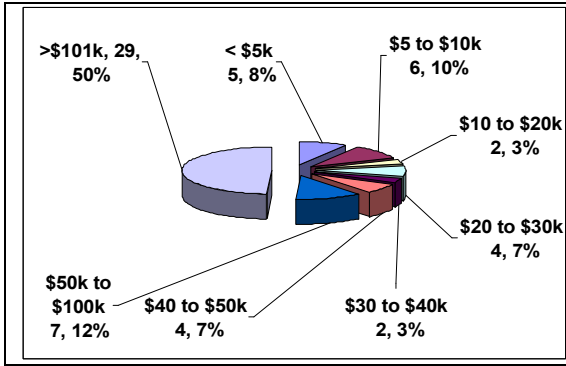


Figure 6. Implementation and Training Cost
 Note: Legend (cost, number respondents, percent)

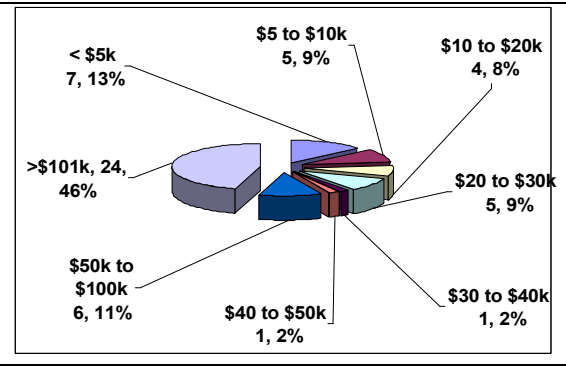


Figure 7. Cost to Maintain Programs
 Note: Legend (years, count, percent)

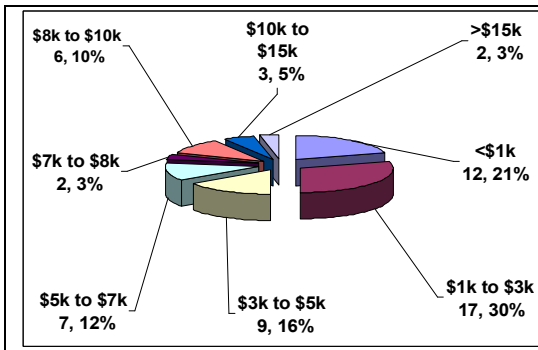


Figure 8. Green Belt Training Cost
 Note: Legend (cost, number respondents, percent)

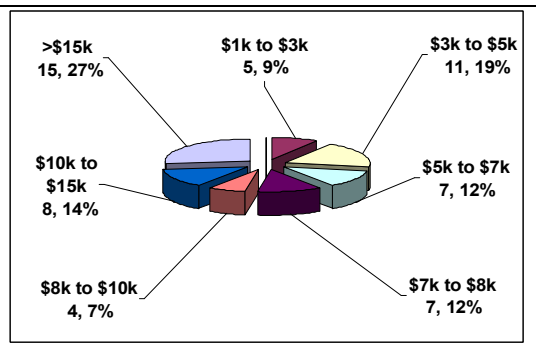


Figure 9. Black Belt Training Cost
 Note: Legend (cost, number respondents, percent)

Sixty-eight of those surveyed reported the total number of personnel employed by their organization. Thirty-two (48%) of those responding stated that their organization was greater than 5,000 employees. Another 5 (7%) stated their organization size to be between 3,001 and 5,000 employees. Only 3 respondents (4%) stated that their organization was less than 20 employees (figure 10). Of the 59 responses to the question about the Green Belt to employee ratio, 33 respondents (55%) reported that the ratio was less than 3 percent (figure 11). The second largest number (10 respondents (17%)) reported a ratio of Green Belt to employees of less than 5%.

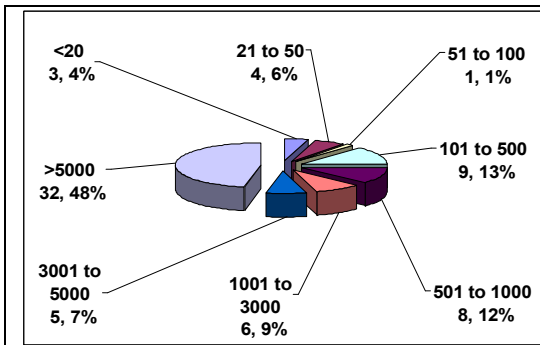


Figure 10. Organization Size
 Note: Legend (size, respondents, percent)

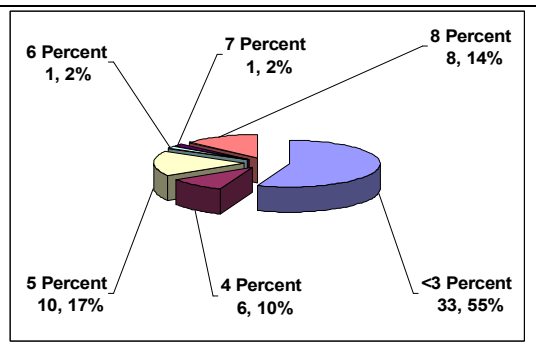


Figure 11. Green Belt Ratio to Employees
 Note: Legend (% ratio, respondents, percent)

Sixty of those surveyed responded to the question that provided the Black Belt to employee ratio. Twenty-nine (48%) stated that their ratio of Black Belt to employees was less than 1%. The final question surveyed the participants for their perception of the average percent of return on investment (ROI) for the first year following program implementation. It is

of interest that of the 70 participants only 59 elected to respond to this question. Thirty-three of those respondents (55%) reported the ROI for the first year of program implementation was less than 3% (figure 11). Another 6 (10%) reported a 4% ROI and 10 (17%) report 5% ROI.

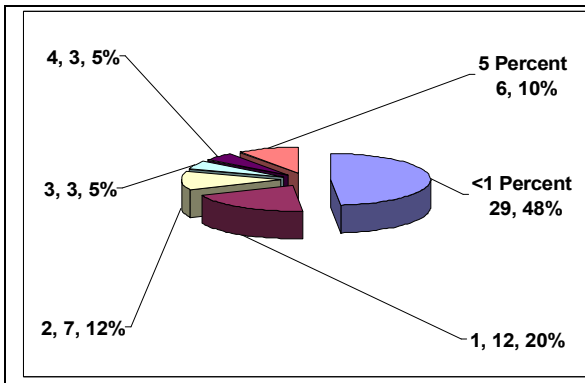


Figure 12. Black Belt Ratio to Employees
Note: Legend (% ratio, respondents, percent)

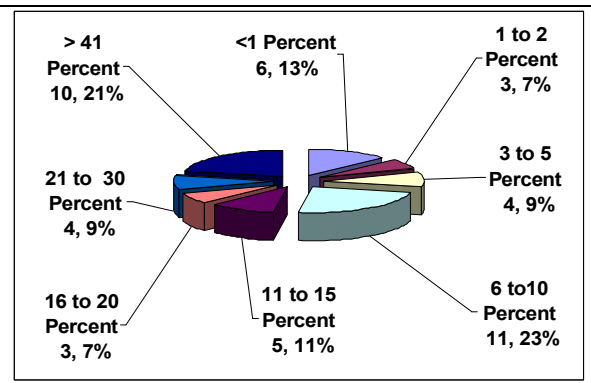


Figure 13. First Year (ROI)
Note: Legend (% ROI, respondents, percent)

3.2 Follow-up Survey Results

Only 60 of the 70 subjects that agreed to participate in the initial survey agreed to continue with the follow-up survey. Of these 60 the maximum number that answered anyone of the survey questions was 50.

In response to the statement, "This discipline has introduced new ideas, methods, and tools into my organization that have positively transformed our business practices", 49 subjects agreed (mean rating = 9.69, median = 10.00, and s = 1.67) (figure 14). In response to the statement, "Since implementation, customer satisfaction has significantly improved", 50 subjects were not quite as enthusiastic but agreed (mean rating = 8.26, median = 9.00, and s = 2.29) (figure 15). Note that one out of 50 respondents disagreed with the majority.

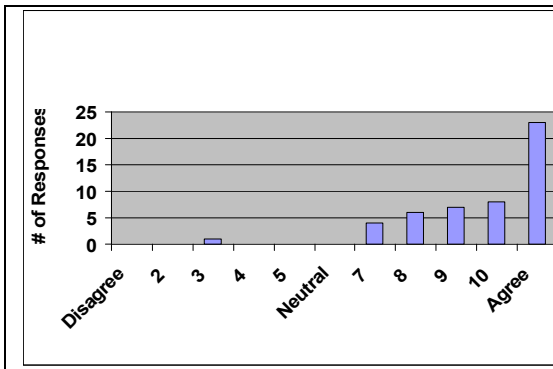


Figure 14. Has Introduced New Ideas

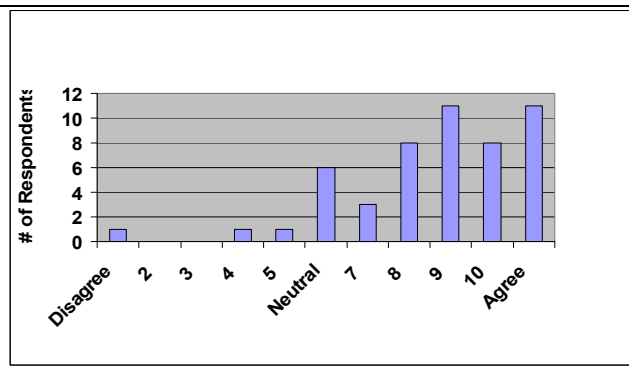


Figure 15. Improved Customer Satisfaction

In response to the statement, "Since implementation, my organization's profitability has significantly improved", 49 subjects agreed (mean rating = 8.26, median = 9.00, and s = 2.29) (figure 16). Responses were bi-modal with 10 slightly agreeing and 12 strongly agreeing that the organization has been more profitable since implementation. In response to the statement, "Since implementation, job satisfaction has significantly increased at my organization", 49 subjects were not quite as enthusiastic but agreed (mean rating = 7.76, median = 8.00, and s = 1.88) (figure 17). Responses to this statement were even less enthusiastic than responses about profitability. One respondent strongly disagreed and 11 strongly agreed that implementing the discipline has improved job satisfaction. The responses were again bi-modal with 12 being neutral and 13 moderately agreeing that job satisfaction had increased.

In response to the statement, "Since implementation, quality has significantly improved", 47 subjects agreed (mean rating = 8.50, median = 8.00, and s = 1.74) (figure 18). Responses were slightly bi-modal with 16 agreeing and 10 strongly agreeing that there has been a significant improvement in quality since the discipline was implemented. In response to the statement, "Since implementation, my organization's competitive advantage has significantly improved", 47 subjects

agreed (mean rating = 8.84, median = 8.00, and $s = 1.75$) (figure 19). The responses were again bi-modal with 12 moderately agreeing and 9 strongly agreeing that the competitive advantage had improved since implementation.

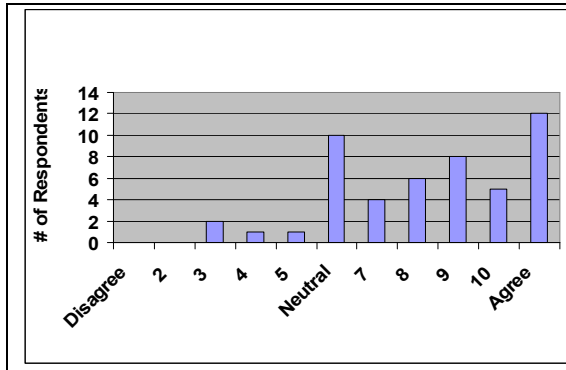


Figure 16. Significant Profitability Increases

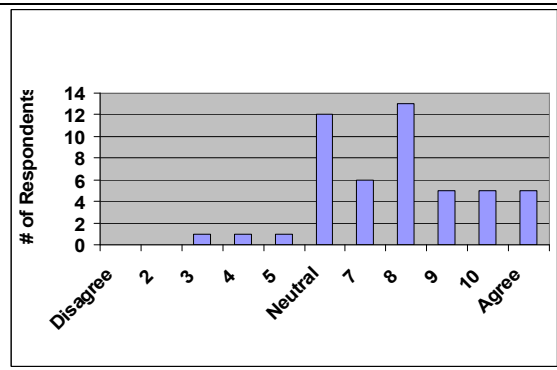


Figure 17. Significant Job Satisfaction Increases

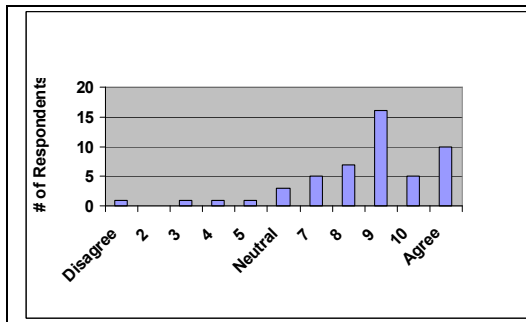


Figure 18. Quality Has Improved

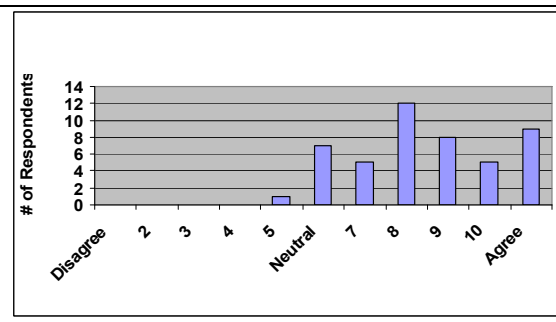


Figure 19. Competitive Advantage Has Improved

In response to the statement, “There are three key principles to be successful at this discipline: pick the right project, get good management support, and execute the DMAIC method”, 48 subjects agreed (mean rating = 8.80, median = 9.00, and $s = 2.78$) (figure 20). Two respondents strongly disagreed with the statement. Responses were bi-modal with 12 agreeing and 19 strongly agreeing that the three key principles to be successful at this discipline are to pick the right project, get good management support, and execute the DMAIC method. In response to the statement, “Communication and leadership skills of a Black Belt are much more important than technical skills”, 49 subjects agreed (mean rating = 7.86, median = 8.00, and $s = 2.86$) (figure 21). Again two subjects strongly disagreed with the statement that communications skills were more important than technical skills. The responses were again bi-modal with 8 moderately agreeing and 11 strongly agreeing that communication skills are more important than technical skills.

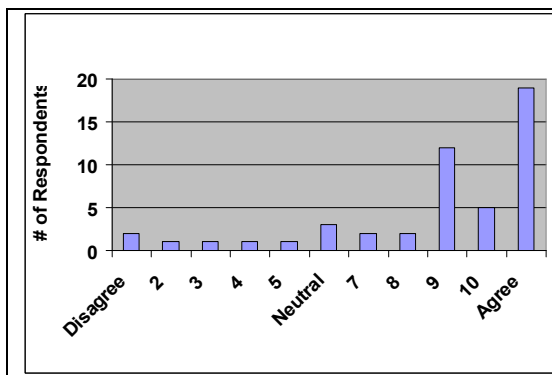


Figure 20. Three Key Principles to be Successful Management Support, and DMAIC

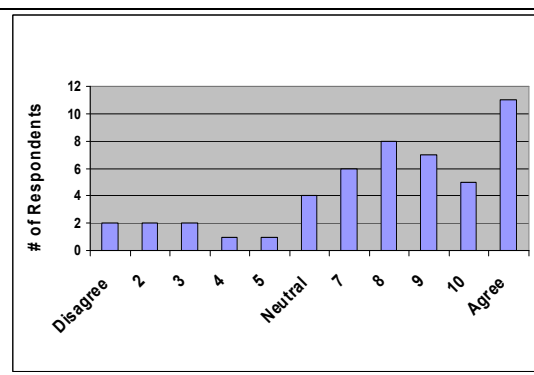


Figure 21. Communication and Leadership Skills are the Project for a Black Belt vs. Technical Skills

4. ANALYSIS

4.1 Initial Survey

The most popular answer for the program used by the respondents' organizations was Lean Six Sigma. Interestingly, seventy-three percent of these organizations had been using the program for five years or less. Two of the respondents said the program had been in place for over 15 years. Lean (Lean) was the second most popular with 56% of these organizations practicing Lean for 3 years. One of the Lean companies implemented the program over 15 years ago. The program with the lowest response percentage was Six Sigma but all but one of the survey participants said the length of time for the system was a minimum of five years with 50% of these being over 10 years.

In response to the initial cost of the implementation and necessary training, the results showed 49.2% at greater than \$101,000 but there were many comments for this question. One comment was *"the cost actually depended on how serious the organization was about the program"*. This implies that two respondents worked for very serious organizations. Alcan, according to one respondent, spent millions implementing Lean Six Sigma five years ago. Another said *"We spent greater than 800K externally for our initial waves of training, we deployed into a 1 billion dollar company."* A Lean respondent said between \$20,001 and \$30,000 was spent the first year for training 50 people. The company then created an internal training program which included the basic PDCA and Lean principles specifically geared for their energy service industry. Using the internal program, 1,000 people were trained for much less than \$7,000. An interesting response that leaves a lot to personal interpretation was *"None ... good training pays an immediate return."*

Forty-five percent of the respondents indicated that the cost of maintaining the program was over \$101,000 per year. An employee for GE, one of the aforementioned founding fathers of the Six Sigma program, explained the over \$101,000 per year in maintenance in comparison to the size of the organization, stating that *"with 330,000 plus employees, and Lean Six Sigma organizations in each business, that's a lot of pure C&B costs."* It is unclear what he or she meant by C&B costs. The Alcan employee said the cost of maintaining was the same as initial implementation. Another said *"If the organization is successful there should be a significant return on the investment, it is self-funding."* A couple of responses said the maintenance costs are mostly based on the salaries of the participating employees. An example of these responses is as follows: *"After the contract consultant completes the project, the cost of sustaining will be the cost of a full time employee to manage the project. This cost will be in the 50,000 to 100,000 range, depending on the size of the project and opportunities remaining."*

Reports on cost of training green and black belts indicated a very large variation. Over fifty percent of the answers reported between three and ten thousand dollars for the black belt training. However, 26.3% said the actual cost was over \$15,000. Likewise, 50% of the respondents answered that green belt training can be done for \$3,000 or less, with 29.3% keeping the answer in the \$1,001 to \$3,000 range. This implies black belt training could possibly cost 5 times as much as green belt training. Several comments were associated with these questions. Comments for the black belt training included two who said the actual figures for training are not revealed while another said the training was done internally. One justified the cost of the training being between \$1,001 and \$3,000 because it was done internally. Another respondent did not actually answer the question but instead offered that the company should make at least \$300,000 per certified black belt. It is unclear if that figure is per year. Green belt training comments included the some who reported that they did not know and two said their organizations are no longer using green belts. One person from Brazil said that in his area training for green belts runs around \$4,000 and certification costs and additional \$160.00. Another included the salary for the Green Belts during their first project as \$50,000 per year. Both questions had two responses of "not applicable (NA)". The NA responses came from individuals Lean (Lean) only. Lean does not utilize "Black Belts" and "Green Belts" per se and the survey actually had 7 participants say they were Lean, not Six Sigma or Lean Six Sigma.

The number of employees in the organization and the ratio of the Black Belts and Green Belts were interesting. Forty-seven percent of the responses said the number of employees was over 5,000. Four people explained in comments that 5,000 was a small number. One of the commentators works for the U.S. Department of Navy, another at an organization with 60,000 employees and yet another's organization has over 200,000 in their workforce. The largest organization was GE which employs over 330,000 worldwide. The percentage getting the highest response for ratio of black belts to employees was less than one percent. There were several comments to this question. Two that were important were that the ratio company-wide was small but was much higher in certain locales and *"There is a misconception about number of black belt to total employees."* It is not clear whether this misconception is internal to the organization or external. Likewise, almost 56% of the answers said the ratio of green belts to company size was below three percent. Two respondents disagreed with the consensus. One said over 80% of the employees were green belts and are required to do a project every other year. Another answered that 90% of the employees were certified green belts and the company policy requires every employee be a green belt at a minimum. This would lead outsiders to believe the answer for this question should have been 100% unless the others are still working on a project to get certification.

The final question of this survey was the nuts and bolts of this analysis. What is the return on investment the first year following the adoption of the program? The largest percentage of answers (23.9%) was 6 to 10% ROI. A very close second

was 21.7% answers claiming a return of 41 to 50%. This question had the most comments of any, a total of 21. Ten of these comments explained that this figure is not one they know. The other 11 comments included 5 which defined higher percentages than the survey choices. These were, in ascending order, 90%, 123%, 150%, 300% and 1,000%. Verbal responses were as follows: *“Each black belt is expected to save \$800K minimum yr,” “4 times the initial investment, we saved >3.5 million the first year,” “3 to 5 times the investment” and “A \$2,500 investment yielded \$2.milliom of cost reduction”*. One comment explained that *“the ROI grows each year following roll out-with strict standards.”* Finally, one participant stated that *“ROI is judged by “times the investment”, not percent of investment.”* He followed up this point by saying a good Lean Consultant should be able to return 5 to 10 times his salary on project savings the first year of the program, depending on the size of the organization. This statement does not conform to the normally accepted definition of ROI that it is the income created from the investment divided by the total cost of the investment. Using the respondent’s definition would create an inflated statistic.

4.2 Follow-up Analysis

The first question in the second survey was an attempt to qualify that new ideas were in fact being introduced in the organization, whether they are new in general or new to the company itself. Ninety-eight percent of the responses were above neutral with 46.9% agreeing completely. Two important comments were submitted. The first said that *“For 4,000 people, cultural transformation demands at least 2 to 3 years. We focused on formal leaders and decision makers to push commitment, and we left available a 2 hrs e-learning training to provide understanding (35% was reached in 2 yrs).”* The second said the new ideas are a source which *“Drives thinking and discussions.”*

The second stated that since the implementation, customer satisfaction had improved significantly. Like the first response, the majority of the respondents felt that this had happened with 82% above neutral. One comment said the implementation actually raised customer’s expectations to some degree. Another said that the customer satisfaction continues to improve, dependent on the focus of the projects the organization is completing.

The third statement claimed the implementation increased profitability. The response to this was still mostly positive with the highest percentage in the above neutral range. Full agreement received 12 responses, the highest in this survey. The neutral response came in a not so distant second with 10 responses. A comment left by a respondent who had agreed that the implementation had increased profitability was *“Until the latest market adjustment!”*

Exploring whether employee job satisfaction improved significantly resulted in the most lukewarm response? The rating receiving the most responses at 13 was two steps above neutral which was also three steps below full agreement. The second place response was neutral with a total of 12 hits. Only 5 of the 50 survey takers were in 100% agreement. One respondent’s organization gave the employees a survey about their program, Lean Six Sigma. The employees rated the program as the best engaged program at our company. Another claimed that employee satisfaction rose from 65% to 99% in two years.

For the statement, *“Since implementation, quality has significantly improved,”* most responses were right in the middle of the positive side of the scale with only 14% or 7 responses at neutral or below. The majority of these 7 were organizations that had implemented Lean only – not Six Sigma or Lean Six Sigma.

The improvement of the organization’s competitive advantage due to implementation was the focus of the next statement. 81.3% of the survey responses were between neutral and agreement. One comment clarified that the business must maintain the edge.

The seventh statement claimed that since implementation the organization had grown. The majority of the responses for this statement were neutral. However, the second highest amount of the responses agreed with this statement. A couple of clarifying comments were made. One stated the organization grew 400% in 4 years. The other comment was about the increasing efficiency in the organization. The respondent said *“We’ve actually reduced some operating groups by increasing efficiency. Heads were not lost, just reassigned.”*

The final two statements were included to assess the survey takers opinion on their applicable programs, 38.8% agreed that the three key principles to be successful was picking the right project, obtaining management support and executing the DMAIC methodology. An additional 42.9% were between neutral and full agreement. 14 comments were left for this statement and are included below:

“I mostly agree BUT... Let’s not forget the DMADV. Additional Note: Although these programs are strict, to execute without flexibility needlessly increases the duration of projects and lowers the benefits.” Editor’s clarification: DMADV, which stands for Define, Measure, Analyze, Design and Verify, is used when a new product needs to be developed or an existing product has been optimized and does not meet the customer specification or the six sigma level.

- “On a simplistic level I think that this is correct but in my experience the key is belief in the process chosen from the top. Then it is consistency (Deming) in applying the approach.”
- “Too simplistic - they matter but it goes beyond that.”
- “Executive Commitment and process owner accountability is key.”
- “Not all Six Sigma methodologies use DMAIC.”

- “Management support is critical.”
- “There is a lot more involved than just doing projects, there needs to be a strategy, an urgency, and the desire to completely transform the organization.”
- “Those three and enable the culture ... data driven, etc.”
- “Not only - I would add open access to training, leaders full commitment, formal help and support team, structure of knowledge multipliers in all areas, good communication, recognition and projects data access.”
- “Agree for DMAIC, but lean can get you there faster.”
- “Management has to lead and be hold responsible.”
- “Not only management buy-in, senior management commitment is crucial to success.”
- “Depends on the project. Some projects require DFSS or a more pure lean workout approach.” Authors’ note: DFSS stands for Design for Six Sigma and is used to design or re-design a product. One DFSS methodology is DMADV mentioned in 4.2.8A.
- “Understand how your business operated in the Lean enterprise.”

Only 22% of the respondents agreed that communication and leadership skills of a Black Belt are much more important than technical skills. 24% fell at neutral or below on this question. One person who disagreed said *“Soft skills are definitely helpful but a strong mandate even more.”* Another who agreed felt communication and leadership are very important regardless of the person’s title. However, *“For it to work properly the role almost needs to be evangelical with a depth of belief that is demonstrated by the behaviors.”*

5. CONCLUSIONS

The survey results are predominantly positive, with responses ranging from consistently high agreement with a positive outcome (new ideas were introduced) to lukewarm or inconsistent at worst (job satisfaction has improved). While survey results are generally quiet supportive of the techniques and would lead to a recommendation for the adoption of one of the programs, it is necessary for there to be further study done. There is a possibility of a positive bias in the current study. The survey was administered to professionals who are employed in some field where implementations have been perceived as successful to one extent or another. Most of the participants were obtained from a network for Six Sigma professionals. Respondents who are more enthusiastic about the survey’s subject matter are typically more likely to respond, so those who have had less positive experiences with Lean, Six Sigma, or Lean Six Sigma may have self-selected themselves out of the survey. Over 20 of the respondents were self-employed consultants who make their living assisting businesses with implementation of one of these quality techniques.

Responses to the estimation of Return on Investment (ROI) associated with the techniques and the perceptions regarding increased profitability were not consistent. In a number of cases, the respondents were not able to estimate an ROI. The ROI calculations that were given were quite diverse and there is no record of who did the calculations or exactly how the calculation was made. A survey of the financial professionals in the responding organizations might either support the claims of high returns or it might refute them

Follow-up research to this survey could also explore situations where the programs did not live up to expectations. There are blog entries that talk informally about negative experiences with the bloggers claiming to hold at least one ASQ certification as a Manager of Quality/Organization Excellence, a Quality Engineer, a Quality Auditor and even Six Sigma Black Belt, with some claiming multiple certifications. The blogs themselves cannot be considered valid reference sources. If the bloggers could be surveyed in a well-structured approach, their negative perceptions might be compared to the positive perceptions of those who have been successful. Some of the respondents to the survey discussed in this article shared that Six Sigma was not for everyone and they had worked with companies where it did not fit. Their analysis was that lack of fit was directly caused by a lack of management commitment – a reason often cited for two other programs (ISO and QS) failures. A comprehensive survey of areas where the result has been disappointing would be worthwhile. Even more valuable than perceptions, objective differences in size, structure, age of the organization, and levels of capitalization might be noted as affecting the relative success of the techniques.

The Sigma programs have also not been through the kind of global economic recession industries are now facing. Studies comparing Lean/Six Sigma companies to other companies as they adapt to hard times could have some worthwhile conclusions. With less money available to spend on the implementation and training phases for the time being, there are likely to be fewer new adopters. Further research would help each company considering the implementation to assess the likelihood of whether the investment will improve the financial performance of the business.

5. REFERENCES

1. Six Sigma Training, History, Definitions – Six Sigma and Quality Management Glossary. (2009). <http://www.businessballs.com/sixsigma.htm>
2. Summers, Donna, C.S. (2007). Six Sigma Basic Tools and Techniques. Pearson Education, Inc., Upper Saddle River, New Jersey, USA.
3. Franco, Vanessa R. (June 2001). Adopting Six Sigma, Quality Digest.
4. The History of Quality – Overview. (2009) <http://www.asq.org/learn-about-quality/history-of-quality/overview/overview.html>
5. Juran, J.M. (1995). History of Managing for Quality: The Evolution, Trends and Future Directions of Managing for Quality. ASQC Quality Press, Milwaukee, Wisconsin, USA.
6. iSixSigma Staff. (2002, August 15). The History of Six Sigma. *iSixSigma.com*. <http://www.isixsigma.com/library/content/c020815a.asp>
7. Harry, M., & Shoreder, R. (2000). Six Sigma, The Breakthrough Management Strategy. Currency/Doubleday, New York, New York, USA.
8. Harry, M., (1998). The Nature of Six Sigma Quality. Motorola University Press, Schaumburg, Illinois, USA.
9. Holland, Charles. (January 2007). Deep-Sixing Six Sigma. Chief Executive Magazine.
10. Hind. B. (June 11, 2007). At 3M, A Struggle Between Efficiency and Creativity. Business Week.

BIOGRAPHICAL SKETCH



Jerusha Myrick, General Manager of Laser Precision Cutting, Inc. in Weaverville, NC, is a 2009 UNC-Asheville graduate with a B.S. degree in Industrial Engineering Management. Mrs. Myrick, a senior member of ASQ, is a ASQ Certified Manager of Quality/Organizational Excellence and a ASQ Certified Quality Auditor. In 2000, Jerusha was recognized by YWCA as a TWIN (Tribute to Women In Industry) Honoree.



Tracy Burkhardt, Business and Financial Analyst at Volvo Construction Equipment Rents, Inc. in Asheville, NC, B.S., Industrial Engineering Management and Managerial Accounting, University of North Carolina at Asheville (UNCA); B.A., German, UNC Asheville; Six Sigma Master Black Belt, Villanova University. She has published research in the National Conference on Undergraduate Research (NCUR) Proceedings and the International Journal for Industrial Engineering Theory, Practice, and Application.



Linda Nelms Professor of Management, University of North Carolina at Asheville (UNCA), B.A., Literature, UNCA; M.B.A., University of North Carolina at Chapel Hill. North Carolina, C.P.A., C.M.A., C.P.I.M. Mrs. Nelms awards include the Ruth and Leon Feldman Professorship for Outstanding University Service and the University Service Council Award. She has published several articles in top tier peer reviewed international journals such as The Management Accountant and conference proceedings to include the Annual International Journal For Industrial Engineering Theory, Practice, and Application Conference. Mrs. Nelms has served as the Director of UNCA's Undergraduate Research Program. Her research interests are in the areas of managerial and accounting ethics, economic analysis, production and inventory control, and other related topics that span the gap between economics, accounting and engineering.



Steve Patch, Professor of Statistics, University of North Carolina at Asheville (UNCA), B.A., Mathematics, University of Connecticut; M.S., Ph.D., Statistics, Clemson University. Dr. Patch's awards include the Ruth and Leon Feldman Professorship for Outstanding University Scholarship and the UNCA Distinguished Teacher of the Year Award. He has published articles in journals including Technometrics, Journal of Environmental Health, and NeuroToxicology. He is currently Director of the Environmental Quality Institute at UNCA. His research interests include applying statistical methodology to industrial processes and to environmental issues.



Robert Yearout Professor of Industrial Engineering Management, University of North Carolina at Asheville (UNCA), B.S.C.E., Virginia Military Institute, M.S.S.M., University of Southern California, M.S., Ph.D., Kansas State University. LTC (US Army Special Forces, Retired). Dr. Yearout's awards include the Ruth and Leon Feldman Professorship for Outstanding Research, Distinguished Teaching Award, and UNCA Distinguished Teacher of the Year, University Service Council Award, and Board of Governors of the University of North Carolina Award for Excellence in Teaching, and Annual University Research Council Award for Scholarly and Creative Achievement. Dr. Yearout has published a significant number of articles in national and international peer reviewed journals such as *IEEE Transactions on RELIABILITY*, *International Journal of Industrial Ergonomics*, and the *International Journal For Industrial Engineering Theory, Application, and Practice* in subject areas directly related to his teaching expertise which includes Quality control and Production and Operations Management. He is the editor for *National Conferences on Undergraduate Research (NCUR) Proceedings* and a member of the Editorial Board for the *International Journal For Industrial Engineering Theory, Practice, and Application*.

Appendix A: Sample Cost for Obtaining Six Sigma Certification

Green or Black Belt	Online or Onsite	Project Certification	Canned Project Data	Length of Course	Cost
Black	Online	No	Yes	NA	\$199
Black	Online	No	No	NA	\$599
Black	Online	Yes	Yes	NA	\$995
Black	Online	Yes	No	NA	\$1495
Black	Online	Yes	Yes	NA	\$2695
Black	Online	Yes	No	NA	\$3095
Black	Online	Yes	Yes	NA	\$3300
Black	Online	Yes	Yes	NA	\$3600
Black	Online	Yes	No	NA	\$4950
Black	Online	Yes	No	NA	\$5495
Black	Online	Yes	No	NA	\$6400
Black	Onsite	Yes	No	4 weeks	\$6500
Black	Online	No	Yes	NA	\$7365
Black	Online	Yes	No	NA	\$7996
Black	Onsite	Yes	No	4 weeks	\$10000
Black	Onsite	Yes	No	4 weeks	\$10925
Black	Onsite	Yes	No	6 weeks	\$12495
Black	Onsite	Yes	No	4 weeks	\$13850
Black	Onsite	Yes	No	5 weeks	\$14950
Green	Online	No	No	NA	\$99
Green	Online	Yes	Yes	NA	\$595
Green	Online	Yes	Yes	NA	\$1275
Green	Online	No	No	NA	\$1500
Green	Onsite	Yes	No	1 week	\$2250
Green	Online	Yes	No	NA	\$2400
Green	Onsite	Yes	No	1 week	\$3950
Green	½ Online, ½ Onsite	Yes	No	1 week +	\$3995
Green	Online	Yes	No	NA	\$4495
Green	Onsite	Yes	No	1 week	\$4950
Green	Onsite	Yes	No	2 weeks	\$5625
Green	Onsite	Yes	No	3 weeks	\$7495